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Systematic and Anatomical Studies on Some Japanese Plants. I.

By

Yoshisuke SATAKE.

With Eleven Figures in the Text.

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1) Systematic Importance of Spodograms in the *Urticales*.

I. INTRODUCTION.

As is generally accepted, principal criteria for systematizing plants have been said to exist in the morphological character of flowers. In recent times, however, these criteria have been greatly extended to the anatomy of plants and to the characters of the gametophytes, such as the development of the embryosacs and pollens, and the process of fertilization.

It is certain that a system in which natural relations between plants ought to be elucidated should be based on all the characteristics possessed by plants, including morphological, anatomical, cytological or even physiological ones. In so stating, there is then hardly a feature which is allowed to escape the attention of systematizers in constituting what is generally considered to be a natural system. Quite recently, a physiological character to be found in the nature of proteins principally contained in seeds is considered by some authors to be an

essential criterion which should furnish the basis for a natural system. This is, however, seriously opposed by others who regard the character of proteins to be not a sole reliable one for making a natural system, but one of many criteria. In short, systematic criteria should be found in every characteristic of plants, be it morphological, anatomical, cytological or even physiological.

Now, as to the morphological characters, it is certain that we have been laying too much stress on the distinction of flowers in systematizing plants. This might be allowed, were flowers the things which could be found in every season of the year. What will be the next subjects for systematizers when flowers are wanting? They should be leaves, which are to be found during the greater part of the year. There are no doubt many characteristics in leaves of a systematic value, i.e. venation, texture, forms, serration and others. Yet there is one feature which, especially in some families, should be considered to be by far the most important for systematizers, i.e. Spodograms.

By the term "Spodograms", as first used by Prof. H. MOLISCH, is meant the microscopic figures which are to be observed in the ashy residue of leaves remaining in a porcelain crucible after having been quite gradually burnt. These figures are formed of the crystals of oxalate salts, silicate bodies, cystoliths and the skeletons of cell-walls incrusted with carbonate or silicate salts. That these spodograms possess a very important systematic character has been greatly emphasized by Prof. H. MOLISCH in his paper entitled "Aschenbild und Pflanzenverwandtschaft". It is through this paper that it was suggested to me by Prof. HAYATA to take up the present subject in some limited order such as *Urticales* in the Japanese flora, for the graduation thesis which has been worked on from the spring of 1927 till that of 1928 and has been revised more or less afterward. In conclusion it is my pleasant duty to express my hearty thanks to Prof. B. HAYATA under whose supervision this work has been executed. Also to Prof. K. SHIBATA and Prof. T. NAKAI I am much indebted for kind advices which they have given me during my work.

June, 1931.

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II. Methods.

The methods with which the present work has been executed are rather simple and may be roughly outlined in the following paragraphs; special treatments are required in some particular cases, but they will be mentioned in their respective cases.

A portion of 3–5 mm. square in the middle of a full-grown leaf is burnt and heated in a porcelain crucible[1], quite gradually so as to obtain the ashes remaining quite white. Heating suddenly is to be carefully avoided, as it makes the ashes dark brown or even black. In the latter case, it is difficult to observe clearly spodograms.

After cooling, take the ashes on a slide glass with a few drops of anilin oil and put a cover glass on it. The latter reagent has the advantage of clarifying the preparation without changing the forms and the constitutions of the ashes. Phenol is sometimes admirably used, as this makes the silicified membrane and silicate bodies peculiarly shining red.

To observe the chemical nature of ashes, we first treat them with 20% hydrochloric acid, and we know that they are carbonate ashes if they are dissolved with bubbles; but if they bubble very little or not at all or are not dissolved they are silicate ashes. Sometimes ashes are found to be partly carbonate and partly silicate.

In case of necessity we put on the ashes on a slide glass a drop of 20% solution of hydrochloric acid, then we have silicate bodies remaining, all the carbonate substances, especially Potassium compounds, being dissolved. In other cases where we have to examine how far the tissue or other things are silicified, we have to treat the ashes with chromo-sulphuric acid, then we have silicified tissue or substance remaining, all other minerals being entirely dissolved.

A permanent preparation of these spodograms is quite easily obtained by adding a few drops of canada-balsam on the ashes on a slide glass or first xylol then balsam. It should be noted that in the permanent preparations thus obtained the figures of crystals which had been first clearly seen, are sometimes entirely lost when examined some weeks after the preparations are made.

1) This porcelain crucible was first used by Molisch. Recently Ohara has used a platinum-plate for this purpose, but Werner has used his special instrument (Veraschungstellerchen) made of aluminium. Kimura and Nakagomi say that a mica-plate is most convenient for ash-production. I have always used the porcelain crucible, as it proved most suitable for my work.

III. General remarks on spodograms in the Urticales.

Spodograms mainly consist of cystoliths, calcium oxalate crystals, silicate bodies and ashy skeletons like inorganic remains of tissue-cells. Ashy residue, as has been explained in some measure in the foregoing pages, shows wonderfully clear figures of ashy skeletons of cellular tissue, when the latter is incrusted with carbonate or silicate salts. The figures are so beautifully outlined under a microscope that one would be apt to take the skeletons for a true cellular tissue, and the existence, distribution and forms of these ashy substances are so characteristic that it seems to us possible to distinguish one genus from another or even one species from another species.

Now I shall offer some general remarks on spodograms which may serve as criteria in the classification of plants.

Cystolith[1]: cystolith is mineral concretion, usually of calcium carbonate on a cellulose stalk, occurring chiefly in special cells of the

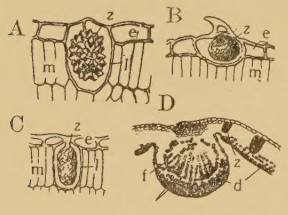

Fig. 1. A-C: Various kinds of cystoliths; A: *Boehmeria frutescens* THUNB.; B: *Morus bombycis* KOIDZ.; C: *Celtis sinensis* PERS. var. *japonica* NAKAI; D: spodograms of the cross section of a leaf of the same species; z: cystolith, l: cystolith-cell, m: mesophyll, e: epidermis, d: clustered crystals, f: solitary crystals. A, B, C = ×160; D = ×40.

Urticales. The forms of cystolith vary, but the most general one is spherical, as seen in a great many species of *Ulmaceae*, *Moraceae* and *Urticaceae*; others are oblong in *Nanocnide*, ovate in *Urtica*, fusiform in *Pilea* and *Pellionia*, or vermiform in *Achudemia*. All cystoliths have many tubercular processes on the surface and appear like bunches of grapes. Cystoliths exist, in many cases, in the epidermal cells or cystolith-cells[2] derived from the epidermal cells of a leaf. For example, the cystoliths of *Morus bombycis* exist in the epidermal cells of a leaf

1) Cystolith was first found in *Ficus elastica* by MEYER and was called "Gummi-Keulen", as he considered it to be a gummy one (1839). PAYEN said, objecting to MEYER's opinion, that it was only a protuberance on a cell-wall which was incrusted with calcium carbonate and called it "Traubenkörper". Cystolith which is now used generally was named by WEDELL (F. KOHL, pp. 115–116).

2) This is called "Lithocysten" by RADLKOFER and "Cystholithenzellen" by DE BARY (O. RINNER, p. 183).

as we see in Fig. 1–B, while those of *Boehmeria frutescens* and *Celtis sinensis* var. *japonica* lie in the cystolith-cells as we see in the same Fig. 1–A, C. Thus the cystoliths of the *Urticales* are always related to epidermal cells. There are two kinds of cystoliths, one is the hair-cystolith and the other the ordinary cystolith (simply called cystolith). The former has, as in *Morus*, a hairy or hair-like protuberance on the outer surface of the cystolith-cell, and the latter, on the contrary, has no protuberance, as in *Celtis*. In some species of the *Ulmaceae* and the *Moraceae*, a kind of cystolith with neither stick nor layer is found; that is what PRIEMER[1] calls "Cystotylen".

Crystals: crystals occur in veins and mesophyll as solitary or clustered crystals (Krystaldruse) of calcium oxalate.

Silicate bodies: silicate bodies such as are found in silica-cells[2] in the leaves of the *Gramineae*, especially in the *Bambuseae*, in conical cells in the *Cyperaceae*, or in stegmata in the *Orchidaceae* are not present in the *Urticales*. However, there are some cells which are more or less silicified, like the epidermal cells surrounding the base of the seta of an *Ulmus* or the hair-cystolith of a *Humulus*. Ashy skeletons are found in the residue of epidermal cell-walls in which silicate or carbonate salts are deposited, of which, when treated with 20% hydrochroric acid, silicate skeletons beautifully remain, but carbonate skeletons break into pieces. There are several kinds of hairs, and they will be explained under each family.

IV. Description of Spodograms.

I. ULMACEAE.

In this family, cystoliths exist only in *Celtis* and *Trema*, but not in the other genera. They occur in the epidermal cells of the upper surface of a leaf, mostly as hair-cystoliths. Crystals occur in veins and mosophyll as solitary or clustered crystals of calcium oxalate. *Ulmus*, *Celtis* and *Aphananthe* have these two kinds of crystals, but *Zelkowa* has only solitary crystals, and *Trema* only clustered crystals. Solitary crystals occur in different places in veins according to genus or species; for example, in *Celtis* and *Ulmus Sieboldii* solitary crystals

1) PRIEMER divides the cystolith-likes into two types—"Cystolithen" and "Cystotylen", and says that the former has either stick or layer, or both of them, while the latter has neither (SOLEREDER, p. 863).

2) H. MOLISCH, pp. 17–23 and Taf. II, Fig. 8, 9, 10.

are present in all veins—the midrib, lateral veins and veinlets, but in *Ulmus* (except *U. Sieboldii*) and *Aphananthe* they exist in the midrib and lateral veins, but not in veinlets. There are two kinds of hairs, one is a seta which is unicellular and incrusted with silicate salts, and the other is an ordinary hair. The seta is mostly on the upper surface of a leaf and has a smooth surface, but in a species like *Aphananthe aspera*, the surface of the seta becomes more or less tubercular. The base of the seta is mostly surrounded by many silicified epidermal cells in which cystotyls are sometimes contained. Ordinary hairs are mostly on the under surface of a leaf and show various forms as in *Ulmus japonica* (Fig. 2–A, h), *Zelkowa serrata* (Fig. 3–C, s″) and *Ulmus laciniata* (Fig. 2–D). Silicification of epidermis is most remarkable in *U. Sieboldii* and *Celtis sinensis* var. *japonica*; in some species where they are not so clearly visible as in the former species, epidermal cells surrounding the base of a seta are remarkably silicified, and especially in *U. laciniata* they have beautiful figures of curved lines (Fig. 2–E, F).

Key to the species.

1 { Cystolith absent 2
  { Cystolith present 6

2 { Both clustered and solitary crystals present 3
  { Only solitary crystals present . . . . . *Zelkowa serrata*

3 { Surface of seta smooth 4
  { Surface of seta rough . . . . . *Aphananthe aspera*

4 { Solitary crystals existing in all veins . . . . . *Ulmus Sieboldii*
  { Solitary crystals existing in the midrib and lateral veins, but not in veinlets 5

5 { Hairs on the under surface of a leaf long and slender . . . . . *Ulmus japonica*
  { Hairs on the under surface of a leaf short and canine-tooth-like . . . . . *Ulmus laciniata*

6 { Both clustered and solitary crystals present . . . . . *Celtis sinensis* var. *japonica*
  { Only clustered crystals present 7

7 { Hairs on the under surface very long and not like the seta on the upper surface . . . . . *Trema orientalis*
  { Hairs on the under surface similar to those on the upper surface . . . . . *Trema amboinensis*

1. *Ulmus japonica* SARG. (Fig. 2–A)

Cystolith none. Clustered crystals rounded, 17 μ in diam., which consist of numerous fine crystals and appear as a globule with the diameter of 10 μ–17 μ, about 250 in number in a square milimeter, uniformly scattered. Solitary crystals rectangular, 20 μ long and 10 μ broad, in the midrib and lateral veins, but not in veinlets. Hairs on

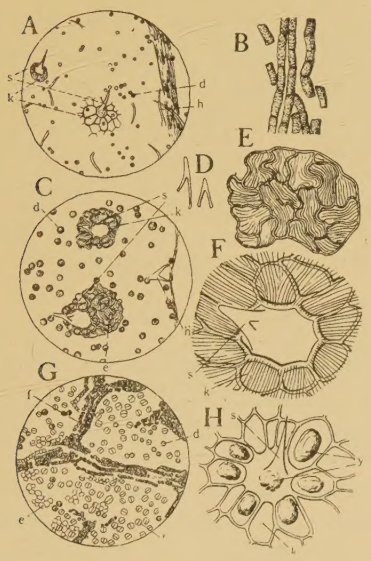

Fig. 2. A: *Ulmus japonica* SARG.; B: solitary crystals in the midrib of the same species; C: *Ulmus laciniata* MAYR.; D: canine-like hair on the under surface of the same species; E: silicified epidermal cells with figure of curved lines, found here and there on the upper surface of the same species; F: seta and its surroundings of the same species: G: *Ulmus Sieboldii* DAVAUX.; H: seta and its surroundings of the same species; s: seta, k: silicified cells surrounding the base of a seta, h: long-slender hair, h′: same as D, d: clustered crystals, f: solitary crystals, e: epidermis, t: stoma, y: cystotyl. A, C, D, G = ×42.5; B, E, F, H = ×175.

the under surface slender, 50 μ–160 μ long, with the base which is 10 μ in diam. Hairs on the upper surface have the nature of a seta 50 μ–160 μ long with the base which is 30 μ in diam. The base of the seta is surrounded by 1–2 circles of epidermal cells which are very well silicified. In the cell under the seta and the cells surrounding it, cystotyls are sometimes found which are very like the cystolith, but with neither stick nor layer of calcium carbonate. Spodograms are transparent and silicification of epidermis is slight.

2. *Ulmus laciniata* MAYR. (Fig. 2–C)

Cystolith none. Clustered crystals rounded, 20 μ in diam., about 250 in number in a square mm., uniformly scattered. Solitary crystals in the midrib and lateral veins, rectangular, 20 μ long and 10 μ broad as in *U. japonica*. Hairs on the under surface are short and like a canine-tooth with thick cell-walls, 50 μ–160 μ long, 50 μ diam. at the base. The base is surrounded by 1–2 circles of well silicified epidermal cells which show beautiful figure of curved lines. Well silicified

epidermal cells on the upper surface are found here and there and show the beautiful figure of curved lines. This is a remarkable characteristic of this species. Spodograms are transparent and well silicified hair-bases and epidermal cells are to be seen here and there, very beautifully bright. Cystotyls are sometimes contained under the base of the hairs.

3. *Ulmus Sieboldii* DAVAUX. (Fig. 2–G)

Cystolith none. Clustered crystals rounded, 10 μ in diam., about 180 in number in a square mm., uniformly scattered. Solitary crystals rectangular, 10 μ long on a side, in all veins and lateral veinlets, crowded together in great number. Hairs, a few on the under surface, and those on the upper surface become sharp and spine-like seta, 50 μ–100 μ long, 30 μ in diam. at the base. The base is surrounded by well silicified epidermal cells in which cystotyls are contained. Epidermis and stomata are very well silicified and their spodograms remain as a beautiful silicate skeleton.

4. *Aphananthe aspera* PLANCH. (Fig. 3–A)

Cystolith none. Clustered crystals rounded, 10 μ–20 μ in diam., about 120 in number in a sq. mm., uniformly scattered. Solitary crystals rectangular, 10 μ long on a side, in the midrib and lateral veins, but

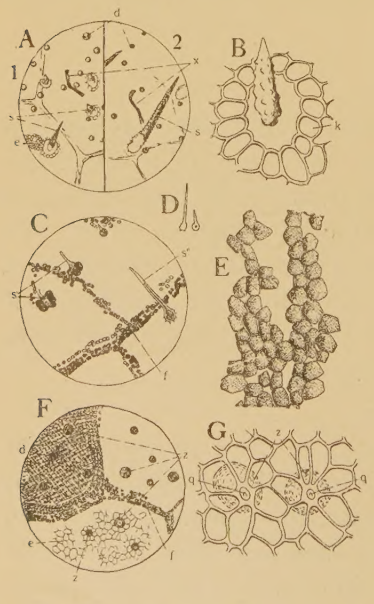

Fig. 3. A: *Aphananthe aspera* PLANCH. (1: upper surface, 2: under surface); B: a small seta on the upper surface of the same species; C: *Zelkowa serrata* MAKINO; D: setae of the same species with no silicified cell at the base; E: solitary crystals of the same species; F: *Celtis sinensis* PERS. var. *japonica* NAKAI (for convenience sake, the figures of cystoliths, clustered crystals and cystolith, and epidermis are drawn separately. In reality, however, they are collectively seen in one and same field under the microscope); G: a part of the upper epidermis of the same species; d: clustered crystals, e: epidermis, f: solitary crystals, x: pieces of vessels of veins, k: silicified epidermal cell surrounding the base of the seta, s: seta with prickly surface, s′: seta, the base of which being surrounded by silicified cells, s″: seta with no silicified cell at the base, z: cystolith, q: small process on the cystolith-cell. A, C, D, F = ×42.5; B, E, G = ×175.

not in veinlets. Seta very big and strong, rough on its surface. This is one of the remarkable characteristics which distinguish this species

from others. The base of the seta is surrounded by well silicified epidermal cells. The seta on the under surface 200 μ–300 μ long and 30 μ–50 μ in diam. at the base; seta on the upper surface smaller than that on the under surface, 30 μ–50 μ, rarely 100 μ long. Epidermis is well silicified and remains here and there as beautiful silicate skeletons. Several pieces of the xylem-remains of veins are seen here and there in the spodograms.

5. *Zelkowa serrata* Makino (Fig. 3–C).

Neither cystolith nor clustered crystal. Solitary crystals in all veins and veinlets are in rows side by side, with various forms—rhombic, rectangular or polygonal. Two kinds of seta are present, one is, as in Fig. 3–s′, surrounded by silicified epidermal cells at the base and are not sharp, while the other is, as in s″, longer and sharper than the former, but is not surrounded by silicified cells. The former about 50 μ long, the latter 100 μ–200 μ long. Spodograms are transparent and epidermis is a little silicified.

6. *Celtis sinensis* Pers. var. *japonica* Nakai (Fig. 3–F).

Cystolith rounded, 30 μ–50 μ in diam., about 40 in number in a sq. mm., uniformly scattered. Outside wall of cystolith-cell possesses a small process and if this process becomes longer, then it is called a hair cystolith. Clustered crystals 10 μ in diam. and are crowded in so large a number that the spodograms become opaque. Solitary crystals in all lateral veins, mostly rectangular. Epidermal cells, especially those surrounding the cystolith are well silicified and remain a beautiful silicate skeleton. Hairs are few.

7. *Trema orientalis* Blume (Fig. 4–A–F).

Remarkable hair-cystolith. There are various forms of hair-cystolith; some have large cystolith-cells with short hairs, or some small

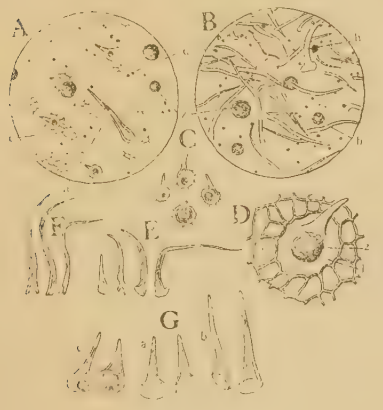

Fig. 4. A–F: *Trema orientalis* Blume; A: upper surface; B: under surface; C: cystolith-hairs; D: a cystolith-hair, more magnified; E: hairs on the upper surface; F: hairs on the under surface; G: *Trema amboinensis* Blume, c: cystolith-hairs, a: hairs on the under surface, b: hairs on the upper surface; d: clustered crystals, e: epidermis, z=cystolith, l: cystolith-cell, h: hair on the upper surface, h′: hair on the under surface. A, B, C, E, F, G = ×42.5; D = ×175.

cystolith-cells with long hairs. Cystolith rounded, 30 μ–50 μ in diam., about 30 in number in a sq. mm., uniformly scattered. Epidermal cells surrounding the cystolith-cell very well silicified. Clustered crystals 10 μ in diam., a few in mesophyll and along lateral veins. Solitary crystals none. Hairs on the upper surface are seta-like. Epidermis on the upper surface are well silicified.

8. *Trema amboinensis* BLUME (Fig. 4–G).

Resembles closely *T. orientalis* in having remarkable hair-cystoliths and in the same properties of spodograms, but distinguishable from it by the less silicified epidermis. Seta on the under surface is the same as that on the upper surface.

II. MORACEAE.

Cystoliths exist in all the genera, except *Vanieria* and *Artocarpus*, rounded or elliptical, about 20μ–30μ in diam. They are found in epidermal cells or in cystolith-cells derived from the former. Whether they are in the upper or the under epidermis depends upon the species. Cystoliths of *Morus bombycis* and *Malaisia tortuosa* are only found in the upper epidermis and those of *Ficus erecta* and *F. foveolata* var. *nipponica* only in the under epidermis, while those of *Broussonetia Kazinoki* are located both in the upper and under epidermis. *Fatoua villosa*, *Humulus japonicus* and *Broussonetia Kazinoki* have remarkable hair-cystoliths.

Crystals of calcium oxalate occur as clustered or solitary. Clustered crystals not above 10 μ in diam. exist commonly in mesophyll, but sometimes in the epidermal cells in *Ficus*, *Artocarpus* and *Vanieria*. MÖBIUS found the existence of clustered crystals in the hypodermis of *Ficus elastica* (SOLEREDER, p. 867). Solitary crystals are observed only in *Vanieria* and *Ficus*.

Hairs are unicellular and seta-like with smooth surface (multicellular hair is rarely found in *Ficus Thunbergii*). On the lateral veins of *Artocarpus*, short thickened silicate hairs with the rough surface are found under the microscope. They are observable with naked eyes and are seen as white points in dry specimens. Silicification of epidermis is not remarkable except *Artocarpus*, *Malaisia* and *Humulus*. The surface of epidermal cells of *Artocarpus incisa* (upper), *Ficus erecta* (under) and *Morus bombycis* (upper) have beautiful figures of curved lines.

Epidermal cells are polygonal, rectangular or elliptical in cross

section; but in *Ficus Thunbergii* and *F. foveolata* var. *nipponica*, the epidermal cell on the under surface has a columnal protuberance whose apex is divided into several stellate arms. Among these columnal protuberances there are many hollows and at the bottom of which stomata exist. Stomata have no subsidiary cells and guard-cells of stomata of *Artocarpus* and *Vanieria* have a very thickened wall.

Key to the species.

1 { Cystolith absent 2
  { Cystolith present 5

2 { Short-thickened silicate hairs with rough surface exist on lateral veins 3
  { No silicate hair above mentioned exists on the lateral veins . . 4

3 { Figure of curved lines present on the epidermal cells . . . . . *Artocarpus incisa*
  { Figure of curved lines absent . . . . . *A. integrifolia*

4 { Clustered crystals exist in the mesophyll and epidermal cells and along the lateral veins; the cell-walls of stomata thickened . . . . . *Vanieria cochinchinensis* var. *gerontogea*
  { Clustered crystals exist along the lateral veins only; cell-walls of stomata not thickened . . . . . *V. trilola*

5 { Remarkable hair-cystolith present 6
  { No remarkable hair-cystolith present; an ordinary cystolith or a cystolith with a short protuberate process 9

6 { Clustered crystals present 7
  { Clustered crystals none . . . . . *Fatoua villosa*

7 { Epidermal cells, especially those surrounding the hair-cystolith very well silicified; hairs few 8
  { Epidermal cells not so well silicified as in the former, but dense slender hairs on the under surface . . . . . *Cannabis sativa*

8 { Cystotyls are contained in the epidermal cells surrounding hair-cystolith, and the surface of epidermis has a figure of curved lines . . . . . *Humulus Lupulus* var. *cordifolius*
  { Not as in the above species . . . . . *H. japonicus*

9 { Only clustered crystals present 10
  { Both clustered and solitary crystals present . . . . . *Ficus foveolata* var. *nipponica*

10 { Cystolith only in the upper epidermis 11
Cystolith both in the upper and under epidermis 12
Cystolith only in the under epidermis . . . . . *Ficus erecta*

11 { Clustered crystals scattered in mesophyll and lateral veins, and epidermis has a figure of curved lines . . . . . *Morus bombycis*
Clustered crystals along the lateral veins; and epidermis has no figure of curved lines . . . . . *Malaisia tortuosa*

12 { Cystolith-cells of the upper epidermis larger than those of the under epidermis; epidermal cells surrounding the cystolith not silicified; cystotyls none . . . . . *Broussonetia Kazinoki*
Cystolith-cells of the upper epidermis smaller than those of the under epidermis; epidermal cells surrounding them well silicified; cystotyls present 13

13 { Clustered crystals under 10 μ in diam., mostly in the midrib and lateral veins; hairs scarecely present. . . . . *Broussonetia Kaempferi*
Clustered crystals 10 μ–20 μ in diam. in all veins and veinlets; dense hairs on the under surface . . . . . *B. papyrifera*

NOTE:—It is beyond question that in genera containing many species as in *Morus* and *Ficus* it is impossible to know one species from another by means of spdograms only. I have therefore here mentioned only some of the remarkable ones which may be regarded as the representatives of such genera.

1. *Artocarpus incisa* LINN. fil. (Fig. 5–A)

Cystolith none. Clustered crystals rounded, 10 μ in diam., about 160 in number in a sq. mm., scattered in mesophyll and epidermal cells. Solitary crystals none. Epidermal cell-walls waved, well silicified, figure of curved lines appearing. There are two kinds of hairs; one is a short thickened silicate hair with rough surface, distributed on the lateral veins on both surfaces and observable as white points in dry specimens, its base being surrounded by a single circle of silicified epidermal cells, while the other is a seta-like, 0,6 mm–0,7 mm long, straight or bent at the apex with smooth surface. Glandular hairs present as in Fig. I–A, g. Stomata with thick cell-walls.

2. *Artocarpus integrifolia* LINN. fil.

Resembles the former species, but is distinguishable from it in having solitary crystals in the upper epidermal cells which have no figure of curved lines.

3. *Vanieria cochinchinensis* LOUR. var. *gerontogea* NAKAI (Fig. 5–F)

Cystolith none. Clustered crystals rounded, 10 μ in diam., in mesophyll and epidermal cells, in two rows along the lateral veins. Solitary

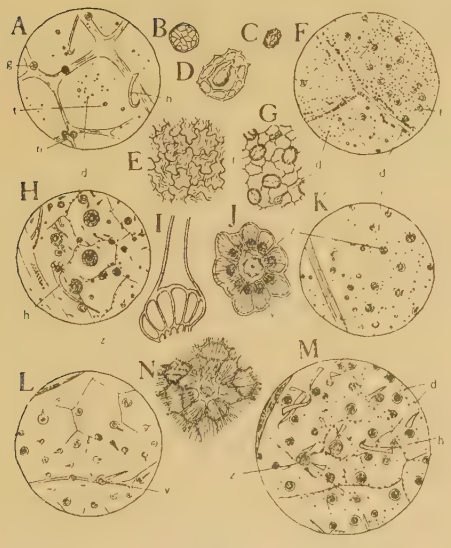

Fig. 5. A: *Artocarpus incisa* Linn. fil.; B: a glandular hair of the same species; C: a stoma of the same species; D: a silicate hair on a vein of the same species; E: upper epidermis with figure of curved lines of the same species; F: *Vanieria cochinchinensis* Lour. var *gerontogea* Nakai ; G: under epidermis of the same species; H: *Humulus japonicus* Sieb. et Zucc.; I: the base of a big and strong seta of the same species; J: a cystolith-hair and silicified cells surrounding the base of the hair of *Humulus Lupulus* Linn. var. *cordifolius* Maxim.; K: *Cannabis sativa* Linn.; L: *Fatoua villosa* Nakai; M: *Morus bombycis* Koidz.; N: cystolith and the upper epidermis of the same species with the figure of radiate lines; z: cystolith, d: clustered crystals, g: glandular hair, v: cystolith-hair, n: silicate hair, t: stoma, h: hair, y: cystotyl, h′: big seta. A, F, H, K, L, M = ×37.5; B, C, D, E, G, I, J, N = ×162.5.

crystals mostly in the midrib. Epidermal cell-walls with irregular protuberances. The cell-walls of stomata thickened, but not so much as in *A. incisa*.

4. *Vanieria trilobа* (Hance) Satake, comb. nov.

Resembles the former species, but is distinguishable from it in having no clustered crystal in mesophyll and non-thickened stomata.

5. *Humulus japonicus* Sieb. et Zucc. (Fig. 5–H)

Hair-cystolith. Cystolith rounded, 20 μ–30 μ in diam., about 100 in number in a sq. mm. in the upper epidermis. Clustered crystals a few, along the lateral veins. Solitary crystals none. Hair is unicellular, seta-like, 0,6 mm. long, on the lateral veins of both surfaces. The base of the hair-cystolith and seta are surrounded by well silicified epidermal cells. Silicification of epidermis is not very remarkable.

6. *Humulus Lupulus* Linn. var. *cordifolius* Maxim. (Fig. 5–J)

Resembles very much *H. japonicus* but is distinguishable from it in having clustered crystals existing always in lateral veins.

7. *Cannabis sativa* Linn. (Fig. 5–K)

Hair-cystolith. Cystolith rounded, 20 μ–30 μ in diam., about 60 in number in a sq. mm., uniformly scattered. Clustered crystals 10 μ, about 200 in number in a sq. mm. in mesophyll and veins. Solitary crystals none. Hairs unicellular, 50 μ–150 μ long, growing densely on the under surface. Silicification of epidermis not remarkable as in *Humulus*.

8. *Fatoua villosa* NAKAI (Fig. 5–L)

Resembles closely the former species, but distinguishable from it in having no clustered crystal.

9. *Morus bombycis* KOIDZUMI (Fig. 5–M)

Hair-cystolith. Cystolith rounded, 30 μ–50 μ in diam., about 60 in number in a sq. mm., scattered in the upper epidermis. Solitary crystals none. Clustered crystals 10 μ in mesophyll and veins. Upper epidermal cells silicified and have figure of curved lines. Hairs unicellular, seta-like, straight or bent towards the apex, about 80 μ–100 μ long.

10. *Malaisia tortuosa* BLANCO (Fig. 6–A)

Cystolith rounded, 20 μ–30 μ in diam., about 250 in number in a sq. mm., uniformly scattered. Cystolith-cell with a rough surface in

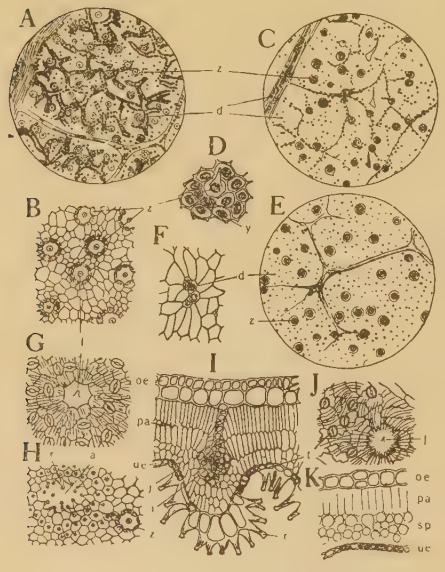

Fig. 6. A: *Malaisia tortuosa* BLANCO; B: upper epidermal cells with 8 cystoliths of the same species; C: *Broussonetia Kazinoki* SIEB.; D: a cystolith-hair on the upper epidermis of *Broussonetia Kaempferi* SIEB.; E: *Ficus erecta* THUNB.; F: upper epidermis with four clustered crystals-cells of the same species; G: cystolith-hair on the under epidermis with figures of radiate lines of the same species; H: under epidermis of *Ficus foveolata* WALL. var. *nipponica* KING; I: cross section of a leaf of the same species; J: under epidermis, and K: cross section of a leaf from a young stem of *Ficus Thunbergii* MAXIM.; z: cystolith, d: clustered crystals, y: cystotyl, l: a process of cystolith-hair, oe: upper epidermis, ue: under epidermis, pa: palisade tissue, sp: spongy tissue, j: parenchym-sheath, i: vascular bundle, r: columnal protuberance of the under epidermis, t: stoma, a: a hollow among columnal protuberances. A, C, E = ×42.5; B, D, F, G, H, I, J, K = ×175.

the upper epidermis. Solitary crystals none. Clustered crystals 10 μ in diam., mostly along the lateral veins. Upper epidermal cells, and especially those surrounding the cystolith-cells well silicified. Hairs scarcely present.

11. *Broussonetia Kazinoki* SIEB. (Fig. 6–C)

Hair-cystoliths exist on both upper and under epidermis. Those on the under surface have small cystoliths and long hairs, while those on the upper surface have large cystoliths and short hairs. Solitary

crystals none. Clustered crystals 10 μ in diam., mostly in the lateral veins. Silicification of epidermis is not very remarkable. Upper epidermis has a beautiful figure of curved lines.

12. *Broussonetia Kaempferi* SIEB. (Fig. 6–D)

Hair-cystoliths on both surfaces. Cystolith on the upper surface rounded, 20 μ–30 μ in diam. surrounded by several circles of well silicified epidermal cells in which cystotyls are contained. Cystolith on the under surface rounded, 30 μ–40 μ in diam. and cystolith-cell-walls become seta-like outside. Cells surrounding the cystolith-cells are not silicified. Solitary crystals none. Clustered crystals, many in the midrib and lateral veins, but a very few in veinlets. Hairs mostly on the under surface.

13. *Broussonetia papyrifera* VENT.

Resembles the former species; but clustered crystals in the present species are larger, 10 μ–20 μ in diam., and much more in number than the former species. This species is also distinguishable from *B. Kaempferi* in having various formed hairs on the under surface, so various as long or short, straight or bent.

14. *Ficus erecta* THUNB. (Fig. 6–E, F, G)

Hair-cystolith. Cystolith rounded, 30 μ–50 μ in diam., 60 in number in a sq. mm., uniformly scattered in the under epidermis. Solitary crystals none. Clustered crystals 8 μ in diam., exist in a large number in the epidermis and mesophyll. Silicification of epidermis not remarkable. The under epidermis has a beautiful figure of curved lines. Hairs scarcely present.

15. *Ficus foveolata* WALL. var. *nipponica* KING (Fig. 6–H, I).

Cystolith rounded, 20 μ–30 μ in diam. in the under epidermis. Cystolith-cells with rough surface. Clustered crystals 10 μ in diam. in lateral veins. Solitary crystals rhombic, in the cells under the epidermis. Silicification of epidermis not remarkable. Epidermal cells on the under surface have columnal protuberances whose apex are divided into several stellate papillae. Many hollows are found among these columnal protuberances on the under surface of a leaf and at the bottom of the hollows stomata exist. Guard-cells of stomata thickened.

NOTE:—The leaves of the group of Ficus with a climbing habit such as *F. foveolata* var. *nipponica*, *F. Thunbergii* and *F. pumila* have a different structure from that of other groups. The epidermal cells on the under surface in the climbing group have columnal protuberances and among the epidermal cells exists depressed areola surrounded by lateral veins and veinlets in which stomata are found (Fig. 6–H, I). If we look at the transversal section of a leaf, we find

that the epidermal cells on the under surface become columnal protuberances and stomata exist at the bottom of the hollows among the protuberances. The structure just given is all the same in *F. Thunbergii* and *F. pumila*. Here is a point which deserves attention. There are differences between the structure of a leaf coming out from a young stem of a species and that from an old stem of the same species. Now, taking for example, *F. Thunbergii*, we see that in a leaf taken from an old stem the epidermal cells are arranged in two layers on the upper surface, but those on the under surface in a single layer possess columnal protuberances, and that the palisade tissue consists of 2–3 layers of cells, but the spongy tissue can hardly be seen as in the case of *F. fovcolata* var. *nipponica* shown in Fig. 6–1. On the contrary, in a leaf from a young stem, as can be seen in Fig. 6–K, epidermal cells on the upper surface are disposed in a single layer, and those on the under surface are also in a single layer, but show no columnal protuberance; and palisade tissue is composed of a single layer while the spongy tissue is clearly seen to consist of 2–3 layers. These differences in the anatomy of a leaf from a young stem on one side and from an old stem on the other are observable even in one and the same species. This is a fact which deserves great attention by the systematizers and anatomists.

3. URTICACEAE

Cystolith exist in all species, mostly rounded or elliptical; but elongate oblong in *Nanocnide;* ovate or irregular elliptical in *Urtica;* fusiform in *Pilea, Elatostema* and *Pellionia*; vermiform in *Achudemia.* They are always contained in the epidermal cells or cystolith-cells. Elongate cystolith of *Nanocnide* or *Pilea* is found parallel to the leaf-surface and a stick in the middle of cystolith is seen on the inside of the upper cell-walls of cystolith-cells (Fig. 8–F, st). Cystoliths occur mostly in the upper epidermal cells, but in *Pilea* they are found in the epidermal cells of both surfaces. Hair-cystolith is rarely found in the species which have stinging hairs. Crystals are seen only in a clustered form. Clustered crystals of calcium oxalate are found in the mesophyll and lateral veins. Silicification of epidermis is remarkable in *Memorialis hirta, Pouzolzia elegans* and *Villebrunea fruticosa*, and when treated with 20% hydrochloric acid, beautiful silcate skeletons remain. In *Villebrunea fruticosa*, epidermal cells surrounding the cystolith-cells are well silicified and become silicate cells (Fig. 8–C, kb). Spodograms of *Laportea bulbifera* manifest a beautiful carbonate skeleton (Fig. 7–D, Cs). Hairs are seta-like and of stinging nature. Long and slender hairs grow densely on the under surface of *Debregeasia edulis* and *Pipturus arborescens.*

Key to the species

1 { Cystolith rounded 2
  { Cystolith not rounded 10

2 { Surface of cystolith papillate, pinion-shaped or deeply wavy . . 3
  { Surface of cystolith nearly smooth or slightly wavy . . . . . *Parietaria debilis* var. *micrantha*

3 { Epidermis well silicified 4
  { Epidermis not silicified 7

4 { Long and strong seta present 5
  { Long and strong seta absent 6

5 { Seta with smooth surface, and clustered crystals none . . . . . *Memorialis hirta*
  { Seta with papillate surface, and clustered crystals present . . . . . *Pouzolzia elegans*

6 { Silicification of epidermis is everywhere seen; long and slender hairs on the under surface . . . . . *Debregeasia edulis*
  { Silicification of epidermis is only remarkable around the cystolith . . . . . *Villebrunea fruticosa*

7 { Cystolith about 160–250 in number in a sq. mm. 8
  { Cystolith about 50–60 in number in a sq. mm. 9

8 { Clustered crystals numerous, about 250 in number in a sq. mm. . . . . *Boehmeria frutescens*
  { Clustered crystals, a few . . . . . *Pipturus arborescens*

9 { Carbonate skeleton present . . . . . *Laportea bulbifera*
  { Carbonate skeleton none . . . . . *Sceptrocnide macrostachya*

10 { Cystolith oblong, ovate or elliptical 11
   { Cystolith fusiform or vermiform 12

11 { Cystolith oblong or elongate oblong . . . *Nanocnide japonica*
   { Cystolith irregular ovate or elliptical . . . . *Urtica Thunbergiana*

12 { Cystolith in the both epidermis of a leaf . . . *Pilea viridissima*.
   { Cystolith in only the upper epidermis of a leaf 13

13 { Cystolith vermiform . . . . . *Achudemia japonica*
   { Cystolith fusiform 14

14 { Clustered crystals 15 μ in diam., about 350 in number in a sq. mm. . . . . *Pellionia minima*
   { Clustered crystals less than 10 μ, and fewer than 180 in number in a sq. mm. . . . . *Elatostema involucrata*

1. *Boehmeria frutescens* THUNB. (Fig. 7–A)

Cystolith rounded, 30 μ–40 μ in diam. with rough surface, about 160 in number in a sq. mm., uniformly scattered in the upper epidermis. Clustered crystals in mesophyll, rounded 8 μ in diam., about 250 in

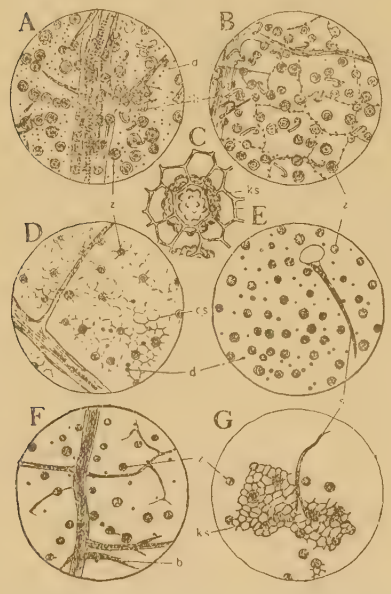

Fig. 7. A: *Boehmeria frutescens* THUNB.; B: *Debregeasia edulis* WEDD.; C: cystolith of the same species; D: *Laportea bulbifera* WEDD.; E: *Pipturus arborescens* ROB.; F: *Sceptrocnide macrostachya* MAXIM.; G: *Memorialis hirta* WEDD.; z: cystolith, d: clustered crystals, s: seta, Ks: silicate skeleton, Cs: carbonate skeleton, b: stinging hair; A, B, D, E, F, G = ×42.5; C = ×175.

number in a sq. mm., uniformly scattered, and these crystals in lateral veins, cubic, 8 μ long, mostly in two rows. Seta on the upper surface and that on the lateral veins on the under surface, 170 μ–340 μ long. Hooked hairs of 50 μ–70 μ long exist on the under surface. Silicification of epidermis is slight, and when treated with 20% HCl, all disappears, except hairs.

2. *Debregeasia edulis* WEDD. (Fig. 7–B)

Cystolith rounded, 30 μ–50 μ in diam. with rough surface, about 100 in number in a sq. mm., uniformly scattered in the upper epidermis. Clustered crystals rounded, 10 μ in diam., in mesophyll and lateral veins. Clustered crystals in lateral veins are arranged side by side in several rows, but those in veinlets are arranged in a single row and are smaller than those in mesophyll. Epidermis well silicified and beautiful silicate skeletons remain after the treatment with HCl. Hairs with hooked apex 80 μ–160 μ long. Long and slender hairs grow densely on the under surface.

3. *Laportea bulbifera* WEDD. (Fig. 7–D)

Cystolith rounded, 30 μ–50 μ in diam. with rough surface, about 50

in number in a sq. mm., uniformly scattered in the upper epidermis. Clustered crystals in mesophyll, 17 μ in diam., and those in veins 8 μ in diam. in several rows. Epidermis remains as a carbonate skeleton.

4. *Pipturus arborescens* Rob. (Fig. 7-E)

Cystolith rounded, 30 μ–50 μ in diam. with rough surface, about 250 in number in a sq. mm. Clustered crystals, a few. The epidermal cells surrounding the cystolith and the base of hair silicified a little. Setae occur on the upper surface, but hooked hairs and long-slender hairs occur on the under surface.

5. *Sceptrocnide macrostachya* Maxim. (Fig. 7-F)

Cystolith rounded, 30 μ, cogwheel-shaped, about 60 in number in a sq. mm. in the upper surface. Clustered crystals rounded, 10 μ–15 μ in diam., about 180 in number in a sq. mm. scattered in mesophyll. Epidermis not silicified. Seta 100 μ–200 μ long, strong and stinging.

6. *Memorialis hirta* Wedd. (Fig. 7-G)

Cystolith rounded, 50 μ–70 μ in diam. with rough surface, about 50 in number in a sq. mm., uniformly scattered in the upper epidermis. Clustered crystals none. Epidermis well silicified and remains a silicate skeleton when treated with HCl. Seta 680 μ long on lateral veins on the under surface.

7. *Pouzolzia elegans* Wedd. (Fig. 8-A)

Cystolith rounded, 30 μ–50 μ in diam. with waved surface, about 80 in number in a sq. mm., uniformly scattered in the upper epidermis. Clustered crystals 10 μ in diam. in the mesophyll. Epidermis well silicified, but not so remarkable as in the former species. Seta 150 μ–350 μ long with many small acute papillae on the surface. This is one of the characteristics of this species.

8. *Villebrunea fruticosa* Nakai (Fig. 8-C)

Cystolith rounded, 40 μ–60 μ in diam. with cogwheel-shaped surface, about 40 in number in a sq. mm., uniformly scattered. Clustered crystals rounded, 10 μ in diam., mostly in lateral veins, and those in veinlets arranged in a single row, but in veins side by side in several rows. Epidermis well silicified, especially those surrounding the cystolith remarkably so and become silicate cells. Long and slender hairs on the under surface and seta on lateral veins.

9. *Parietaria debilis* Forst. var. *micrantha* Wedd. (Fig. 8 D)

Cystolith rounded, 30 μ–50 μ in diam. with slightly wavy surface or

nearly smooth, about 60 in number in a sq. mm., uniformly scattered. Clustered crystals none. Seta 150 μ–250 μ long.

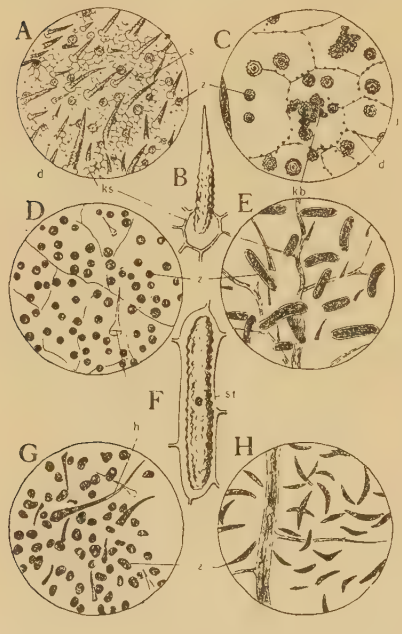

Fig. 8. A: *Pouzolzia elegans* WEDD.; B: the seta of the same species; C: *Villebrunea fruticosa* NAKAI; D: *Parietaria debils* FORST. var. *micrantha* WEDD.; E: *Nanocnide japonica* BLUME; F: the cystolith of the same species; G: *Urtica Thunbergiana* SIEB. et ZUCC.; H: *Pilea viridissima* MAKINO; z: cystolith, d: clustered crystals, s: seta, Ks: silicate skeleton, Kb: silicate cell, st: stick of cystolith. A, C, D, E, G, H = ×42.5; B, F = ×175.

10. *Nanocnide japonica* BLUME (Fig. 8–E)

Cystolith oblong or elongate oblong, 85 μ–170 μ long and 30 μ–40 μ broad, with small rough surface, about 30 in number in a sq. mm., uniformly scattered in the upper epidermis. Clustered crystals none. Epidermis not silicified. Stinging hairs 100 μ–300 μ long.

11. *Urtica Thunbergiana* SIEB. et ZUCC. (Fig. 8–G)

Cystolith irregular elliptical or ovate, 50 μ–80 μ long and broad, with wavy surface, but 60 in number in a sq. mm., uniformly scattered in the upper epidermis. Epidermis a little silicified. Stinging hairs 300 μ–500 μ long.

12. *Pilea viridissima* MAKINO (Fig. 8–H)

Cystolith fusiform, curved a little, 100 μ–300 μ long and 20 μ–30 μ broad in the middle, with rough surface, about 60 in number in a sq. mm. uniformly scattered in both upper and under surfaces. Clustered crystals none.

13. *Achudemia japonica* MAXIM. (Fig. 9–A)

Cystolith vermiform, 150 μ–350 μ long and 30 μ–40 μ broad, with a

rough surface, about 30 in number in a sq. mm., uniformly scattered in the upper epidermis. Clustered crystals a few.

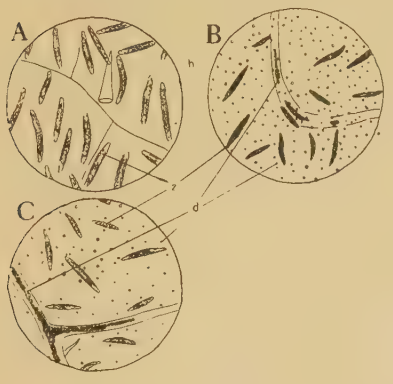

Fig. 9. A: *Achudemia japonica* Maxim.; B: *Pellionia minima* Makino; C: *Elatostema involucrata* Fr. et Sav. z: cystolith, d: clustered crystals, h: a hair. A, B, C= ×42.5.

14. *Pellionia minima* Makino (Fig. 9–B).

Cystolith fusiform, 150 μ–200 μ long and 10 μ–20 μ broad in the middle, with small protuberances on the surface, about 20–30 in number in a sq. mm. in the upper epidermis. Clustered crystals rounded, 15 μ in diam., about 350 in number in a sq. mm., uniformly scattered in the mesophyll, and those in veins, cubic in shape, 10 μ long on one side, arranged side by side in several rows.

15. *Elatostema involucrata* Fr. et Sav. (Fig. 9–C)

Cystolith fusiform, 150 μ–200 μ long and 10 μ–20 μ broad in the middle, with small protuberances on the surface, about 20 in number in a sq. mm. in the upper epidermis. Clustered crystals in the mesophyll, rounded, 10 μ in diam., about 200 in number in a sq. mm., uniformly scattered, and those in veins, cubic in shape, arranged side by side. Epidermis is silicified here and there.

V. Taxonomic value of spodograms and their systematic importance in the Urticales.

As to the cystolith, there is an early study of Weddell who states that the *Urticaceae* may be divided into several tribes or genera according to the shapes of cystolith—punctiform, liniform, fusiform or oblong-elliptical. Hobein says that the presence or absence of cystolith, their forms, the places of their occurrence, their being solitary or clustered, their being acuminate or rounded at the apex may be criteria for classifying tribes or genera in the *Acanthaceae*. Thus the occurrence of cystoliths and their forms are said to show the characteristics of species

or genera. In the spodograms too, the cystolith is the most important thing which deserves careful attention. Next comes the crystals of calcium oxalate—solitary or clustered, as one of the most important criteria. Again it is to be understood that crystals should be regarded all the more important for a systematizer, when we see that NIEDENZU classifies the *Hamamelidaceae* into two groups—I) *Bucklandioideae* and 2) *Hamamelioideae*, according as they possess clustered or solitary crystals in the mesophyll. It is easily considered that to classify genera and in some special cases to determine species is not impossible by characters shown by spodograms which possess the remains of tissue and hairs together with chemical substance.

It is beyond question that there are some differences in inorganic substance secreted in the tissue, in the presence or absence of the same substance, in its mass or distribution, in different plants, as the latter each possess different structures and different physiological functions. It is, therefore, most probable that we can classify plants through spodograms up to the limit of genera. In comparing the analytical keys mentioned in the present paper and the system established by ENGLER, we see that there are not a few points agreeing in the two—one of ENGLER's system and the other of my keys. Consequently we are apt to think that the classification of plants by means of spodograms can never be treated as an awkward one, but may be regarded as convenient and helpful, as the method may be carried on when flowers are wanting.

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2. Systematic Anatomy of Hakonechloa macra MAKINO.

The present dwarf reed, had deen referred to the genus *Phragmites* until 1912 when Dr. MAKINO[1] established a new genus *Hakonechloa* for it. He regarded this reed to be the sole representative of his new genus and called it as *Hakonechloa macra* MAKINO. Some time ago I had an opportunity of comparing the anatomy of the common reed, *Phragmites communis*, and that of *Hakonechloa macra*, and found that the opinion of Dr. MAKINO was quite correct, who distinguished his new genus from *Phragmites*. I shall briefly describe the result of my studies in the following pages.

Morphologically speaking, the leaf of *Hakonechloa* is disposed upside down, that is to say the leaf surface which originally ought to be the upper one, is turned downwards, and that which originally ought to be the under one is turned upwards. Consequently while the leaves of

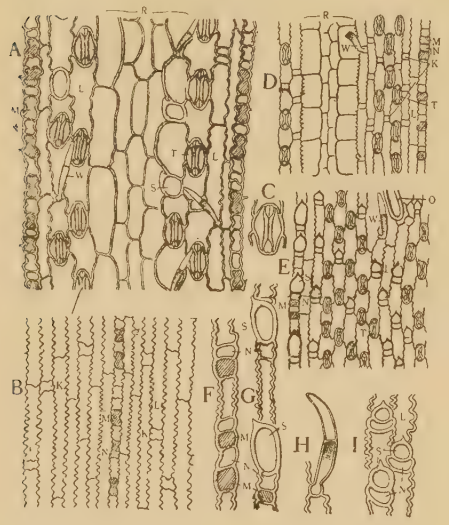

Fig. 10. A–C: *Hakonechloa macra* MAKINO; D–I: *Phragmites communis* TRIN.; A: upper epidermis (morphologically speaking) of the leaf of *Hakonechloa macra* MAKINO; B: under epidermis of the same species; C: a stoma on the upper epidermis; D: upper epidermis of the leaf of *Phragmites communis* TRIN.; E: under epidermis of the same species; F: epidermal cells on the vein of the upper surface; G: epidermal cells on the vein of the under surface; H: an angle-hair on the under surface; I: epidermal cells on the assimilation-tissue of the under surface; L: long cell, K: short cell, M: silica-cell, N: cork-cell, W: angle-hair, S: spine cell, O: seta-like hair, T: stoma, R: articulation cells. A, B, D, E = ×100; C, F, G, H, I = ×240.

ordinary grasses are rolled on the upper surface, those of the present species are rolled on the under surface. Now let us first observe the

1) MAKINO, T.—Observations of the Flora of Japan, in Bot. Mag. Tokyo, Vol. XXVI. (1912), p. 237 and Vol. XXVIII. p. 23.

leaf of the dwarf reed. The epidermis of the under surface (apparently the upper surface) consists principally of long rectangular cells locating above the assimilation tissue. Their long sides are parallel to the veins and the shorter ones are right-angled to them. Cell-walls are remarkably wavy. At the place where these cells touch one another on their shorter sides, there is found here and there a small cell or shorter cell which has the same breadth as the longer cells and is inserted between the two latter. The part of the epidermis which lies on veins consists of shorter cells connecting longitudinally. Beautiful cocoon-shaped silica-cells containing much of silica are found here and there.

The epidermis of the upper surface (apparently under surface) is more complicatedly constructed. Those epidermal cells which exist on the veins are of two kinds, one being shorter cells and the other silica-cells. They are arranged alternately and in a single row. Silica-cells are sometimes suffixed with another kind of cells. The latter are named cork-cells. For convenience sake, I call this row of cells (shorter cells, and silica- and cork-cells) the supravenal band. On both sides of the latter band there exist stomata-bands with stomata mostly in two rows just above the assimilation tissue. Between two stomata-bands, there is another band consisting of larger cells arranged mostly in 4–5 rows. This band is called articulation band which controls the opening and closing of leaves. Among the cells constituting stomata-bands, those cells adjoining the articulation band may become spine-cells, stoma-cells or two celled angle-hairs, according to circumstances. Between a stoma-band and a supravenal (those parts of epidermis which lie on veins) band, there is a band of ordinary longer cells whose longer side is remarkably wavy and whose shorter side is mostly next to a stoma or next to an angle-hair. The latter hair consists of 2-cells, the basal one is strong and thick-walled and the upper one is fragile. As articulation bands are those which are usually found on the upper surface (morphologically speaking) of the leaves of the *Gramineae*, it should be concluded that in the present species too that surface, where the same articulation bands are found, must morphologically be the upper surface. But, as the above statements indicate, in *Hakonechloa*, the surface with articulation bands is turned downwards and the other surface is turned upwards. This is why the present species is called "Urahagusa" (whose literal meaning is a grass with leaves disposed upside down).

But the structure of the epidermis of the under surface of the *Phragmites* is totally different from that of *Hakonechloa*. In the latter species, larger cells are connected with shorter cells, but in *Phragmites*

in the place where a shorter cell lies in *Hakonechloa* we find a stoma, or a cork-cell with a spine cell on it, or angle-hair or a seta-like hair. Again we see another difference in the supravenal epidermis. In *Phragmites*, there are unmistakably large spine cells next to the cork-cell. Thus we find several differences in the epidermal structure of the two species which quite justify Dr. MAKINO's opinion of separating them generically. Now examine the cross sections of the leaves of the two grasses, we shall find another difference which emphasizes more the correctness of this view. In *Hakonechloa*, the cross section of the articulation band is boat-shaped, and the mesophyll consists of a single

Fig. 11. A: cross section of the leaf of *Phragmites communis*; B: cross section of the leaf of *Hakonechloa macra*; G: articulation cells, P: parenchyma sheath, W: wrinkle-cell, S: stoma, Pa: palisade tissue, E: epidermal cell, Sp: spongy tissue. A, B= ×240.

layer of palisade tissue, and spongy tissue, while in *Phragmites* the cross section of articulation band is Y-shaped, the basal part of which is inserted in the tissue of the mesophyll, and cells of the latter tissue are all alike and have inner wrinkles, showing no difference between palisade and spongy tissue. As is mentioned above, *Hakonechloa* and *Phragmites* are totally different from each other in view of the structure of the epidermis and that of the mesophyll, and therefore I have considered the generic separation of the two plants to be quite correct. Finally I shall mention for convenience sake the differences of the two species in the form of a table.

	Hakonechloa macra	*Phragmites communis*
Articulation bands	Band broader, boat-shaped in cross section	Band narrower, Y-shaped in cross section, inserted with its basal portion deep in the mesophyll
Under surface	Neither stoma, nor angle-hair, nor seta-like hair	Stoma, spine cell, or seta-like hair present
Mesophyll	Cells without inner wrinkle, palisade and spongy tissue differentiated	All cells with inner wrinkles, no difference between the palisade and spongy tissue

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